Designing a Tourism Minibus Driver Chair by Using IDEAS Framework in a Virtual Environment

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Abstract
Indonesia is a high tourism sector country which provides opportunities for tour and travel service business. Thereby increasing the growth rate of accidents by 3.3%, one of which was caused by buses. Hafizh 58 Jaya, a company in the field of tourism services, had many complaints against drivers about the problem of muscle disorders due to the lack of ergonomic position of the driver or the seat used which was not suitable with the user or not ergonomic. To analyse this problem, IDEAS framework was applied. This method could describe overall minibus driver movement and produce designs that were appropriate with the level of risk on small musculoskeletal disorders. By normal driving activity, the second driver had the largest PEI parameter index value, 2,186. It was categorized as medium to low-risk musculoskeletal disorders. This meant that the actual chair with normal driving activity was not optimal and not ergonomic. The final design of the redesign chair has given optimal and ergonomic results shown by highest PEI index parameter value of 1,336. This PEI index parameter was categorized at the low risk of musculoskeletal disorders.

Keywords: *Ergonomic, IDEAS Framework, PEI.*

Abstrak
Indonesia dengan sektor pariwisata yang sangat tinggi, membuka peluang usaha bagi penyedia jasa tour dan travel. Hal ini berdampak pada meningkatnya pertumbuhan tingkat kecelakaan yaitu sebesar 3,3%, yang salah satunya dari angkutan bus antar kota. Hafizh 58 Jaya adalah perusahaan jasa pariwisata yang mempunyai banyak keluhan dari para drivernya, hal yang dipermasalahkan adalah gangguan otot, yang terjadi karena posisi driver atau kursi driver yang kurang ergonomis. Untuk menganalisis permasalahan ini digunakan framework IDEAS. Metode ini dapat menggambarkan pergerakan driver minibus secara keseluruhan dan dapat menghasilkan disain produk yang sesuai dengan tingkat risiko minimal cedera musculoskeletal disorders. Dengan aktivitas menyetir keadaan normal pada driver 2 memiliki nilai indeks parameter PEI terbesar yaitu 2,186. Nilai tersebut dikategorikan risiko cedera musculoskeletal

disorders menengah kebawah. Artinya kursi aktual dengan aktivitas menyetir keadaan normal belum optimal dan kurang ergonomis. Hasil akhir rancangan kursi redesign sudah memberikan hasil yang optimal dan ergonomis, dengan nilai parameter indeks PEI terbesar sebesar 1,336 yang dikategorikan sebagai cidera ringan.

Kata Kunci: *Ergonomi, Framework IDEAS, PEI.*

1. Introduction

Nowadays, the traffic system in Indonesia experiences a growth rate of accident cases of 3.3% per year, one of which is caused by buses. Starting from the bus drivers who are tired with conditions that are required to drive for long hours, fatigue, to the drowsiness that often afflicts bus drivers and others. In this research, the case study took a place in Hafizh 58 Jaya Surabaya tour & travel service provider. It is located on Banyu Urip Street No 201 and established in 2019. The initial problem occurred because the researchers ever used the Hafizh 58 Jaya minibus from Surabaya to Blitar and found that a driver who had a thaw on the left leg. Then an interview was made about the problems that were experienced by the Hafizh 58 Jaya Surabaya minibus driver especially to the driver who had complaints of waist pain, and the neck became tense, the legs were often tingling and aching, due to the driver's lack of ergonomic position or due to the seat which was not suitable to the user or not ergonomic, so that made the driver feel tired or pain in the back, neck, or pain in the legs on the journey taken for 6 hours or more.

In this study the Identify, Design, Evaluate, Adapt, and Sustain (IDEAS) framework were used by measuring the parameters of the Posture Evaluation Index (PEI) through the stages of the Low Back Analysis (LBA) method, Rapid Upper Limb Assessment (RULA), and Ovako Working Analysis System (OWAS). The use of these methods was more suitable in the problems encountered by researchers so that improvements were made to the minibus driver seat. This method could define the whole movement of minibus drivers and provide product designs that were appropriate to the level of small risk. The results of this study were to determine the level of risk caused by posture when driving a minibus, provide recommendations for improving the design of the driver's seat to reduce musculoskeletal disorders, so, it will provide comfort and safety for the minibus driver (Muslim et al., 2010; Muslim and Nurtjahro, 2011; Heni et al., 2017).

2. Method

IDEAS is a framework that applies problem solving through 5 (five) ways, with the use from beginning to end identifying a problem between a job and its work environment then providing a solution (Pringgabaya & Prastawa, 2017). First of the identify stage, at this stage the identification of problems will occur starting from the collection of observed object data, data taken starting from height, weight, body posture when doing activities, and observed object dimensions. The second stage, namely design, in the second stage will be done designing images that simulate the dimensions of the object under study (Muslim and Nurtjahro, 2011). This stage will draw both 2 and 3 dimensions of the object by using AutoCAD software. The third stage is evaluating, this stage will evaluate through the calculation of PEI, which includes LBA, OWAS, RULA or Rapid Entire Body Assessment (REBA) which will be assessed by Jack 8.4 software (Qing et al., 2017; Zhang et al. 2019).

PEI is a score parameter in the posture assesment which include LBA method and integrate to another research such as OWAS and RULA (Paramita, 2012). The result of three methodes are able to give assesment for working operation or in the working or researched environment. PEI were applied to optimize the working environment or even working operation system in the ergonomics side

The LBA calculation aims to find out the pressure that is experienced by the spinal column especially about pressure and force which happens due to the activity of workers (Paramita, 2012). This method aims to illustrate the working position which has or has not been appropriate with the parameter in side of ergonomics aspect. Moreover, pressure force, and strain in the lumbar 4 and 5 in the spine were calculated and the results of assessment were below 3400 N (as NIOSH recomendation).

On the 1993, an ergonomist from University of Nottingham (University's Nottingham Institute of Occupational Ergonomics) Dr. Lynn Mc Attamney and Dr. Nigel Corlett were a RULA developer which was shown on journal of ergonomic application (Dzikrillah and Yuliani, 2017). RULA is applied to determine the risks of skeletal muscle posture in more detail at the top of the body. This method measure on hands, upper arm, lower arm, back, neck, calculating the carry load, the force that used, and the number of job (Budiman and Setyaningrum, 2012). RULA can be divided into two groups, those are:

1. Group A, the arm position consist of upper and lower arm, and the hand which consist of wrist and the rotation of wrist.
2. Group B, back area and neck

REBA is used to determine the risk of skeletal muscle posture throughout the body. REBA assessment is performed by observing of the limbs and most frequent functioned body postures, paying close attention to extreme joint angles, duration, forces. First, observations are made of the trunk, neck, and legs. The postures are signed with a numerical value to show the deviation value. Then a posture score is determined by using the numerical values of the previous observations (Jadhav et al. 2014).

The four analyses will be assessed through task analysis tools from Jack 8.4 software. In the fourth and fifth stages, namely adapt and sustain. In the adapt and sustain section, redesigning objects based on the used dimensions will then be reassessed by using PEI and compared to the existing condition. The results of object with the smallest PEI value that addresses the lowest musculoskeletal risk disorders then will be chosen. (Rahmah et al., 2016; Khandan et al., 2018).

3. Result and Discussion

Step 1: Identify

This identification phase is the initial stage of the IDEAS framework. At this stage, a transition will be made while the driver is working, from this transition the complicated situation will be showed up by the driver. In the identification step, the collected data were completed based on the condition of driving, driver sample, questionnaire of Nordic Body Map (NBM), anthropometry measurement, and the actual chair size.

Driver Problem Identification

From the initial interview conducted by researchers, the driver often complained about the legs that were too difficult caused by lack of seat sliders, so many drivers complained of cramps that often occur in their calf, shoulder, walking arms, and legs. The driver also complained about the part of head cushions that were not comfortable, causing the neck to become sore due to the inconvenience of seat cushion. The back rest was too straight, so it was not comfortable for the driver. Problems occurred that drivers often experience complaints caused by driving activities in workplace conditions that were not ergonomic.

Table 1. Driver Activity and Risk that Might Happen

Movement	Documentation	Risk
Driver drives normally		Neck, back, wrists, arms, ankles, calves, and shoulders
The driver holds the turn signal light		Wrists, arms, and shoulders
The driver holds gear		Neck, arms, arms, legs, calves, and shoulders

Movement	Documentation	Risk
The driver holds handbreak		Neck, moves, arms and shoulders

Nordic Body Map (NBM) Questionnaire

Sampling of the data questionnaire was using purposive techniques. The sampling criteria was the drivers who have driven the Elp NKR minibus 19-seater, with a minimum of 5 times experiences, more than 6 hours in a single drive, and more than 6 months of a working period. According to the required criteria, only 4 people can be treated as participants and referred as Driver 1, Driver 2, Driver 3, and Driver 4. In completing the NBM questionnaire, the researcher categorized by using 1 to 4 scale with 1 as the lowest and 4 as the highest of feeling pain. These data will be a guidance to make a better seat to prevent musculoskeletal disorder that has been complained by the driver. The result of feeling pain is shown in Table 2.

Table 2. Result of Feeling Pain

Driver Code	Total of Pain
1	39
2	46
3	50
4	48

Anthropometric Data Drivers

The anthropometric data used in this calculation were taken from drivers who had completed the NBM questionnaire. The data will be used in filling body size data on the mannequins in Jack 8.4 software. Anthropometric data measurement of the driver's body height, sitting height, shoulder height to body weight of the driver can be seen on Table 3.

Table 3. Anthropometric Driver Data

Dimension Code	Location	Driver Code (cm)			
		1	2	3	4
D1	Body height	161	170	167	174
D8	Buttock-knee length	78	85	80	87
D10	Shoulder height, sitting	55	61	58	57
D14	popliteal length	39	38	35	34
D16	Popliteal height	39	39	35	46
D18	Shoulder breadth	40	44	39	45
D19	Hip breadth, sitting	36	45	34	36
D27	Head breadth	19	19	17	18
	Body Weight	80 kg	113 kg	50 kg	70 kg

Seat Size Data

The minibus seat size data was measured by using a meter and the seat shape was detected by using a camera. The tools aimed to make it easier to design in a virtual form. The data on the size of Elp NKR minibus seats owned by Hafizh 58 Jaya can be seen on Table 4.

Table 4. Actual Driver Chair Size

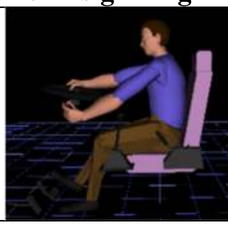
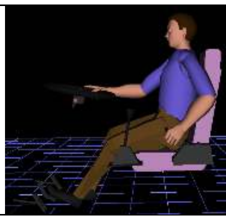
No.	Dimension	Measures (cm)
1.	Head support length	10
2.	Seat depth length	38
3.	Seat length	48
4.	Head support height	11
5.	Chair height	75
6.	Seat height	36
7.	Seat thickness	11
8.	Backrest height	44
9.	Maximum backrest slope	100°
10.	Headrest width	30
11.	Seat width	44
12.	Backrest width	44

Step 2: Design

After the identification stage, the next step is a designing stage. At this stage the following steps will be carried out by making actual chair designs in 2 and 3 dimensions, creating of a virtual environments and driver activity movements.

The shape of the virtual environment has been adapted to the actual shape of the environment, with the base size of the minibus driver with a bottom distance of the seat by 25 cm. The distance between the gas pedal and the seat portion was 44 cm, then the pedal section had 3 parts namely the gas pedal, middle brake pedal, and clutch pedal on the left. The distance between the accelerator and the brake pedal was 9 cm, then the brake pedal and clutch pedal had 19 cm. After the formation of the virtual environment, the formation of a human model body will then be adjusted to some movements in driving. Some of the movements that the driver has made in Jack 8.4 software were displayed on the Table 5.

Table 5. Human Model in Jack 8.4 Software

Movement	**Driver drives normally**	**The driver holds the turn signal light**
Illustration by using Jack 8.4 software		
Movement	**The driver holds gear**	**The driver holds handbreak**
Illustration by using Jack 8.4 software		

Step 3: Evaluation

After designing step, the next step is evaluation. In this step PEI, LBA, OWAS, and RULA will be calculated. After LBA, OWAS, and RULA value were taken in the Jack software, PEI parameter can be detected to get all the value of driver seat posture. The details value of PEI, LBA, OWAS, and RULA are shown in Table 6.

Table 6. Evaluation Score

Driver Code	**Activity**	**PEI**	**LBA**	**OWAS**	**RULA**
1	Driver drives normally	1,84	1105	2	5
	The driver holds the turn signal light	1,83	1067	2	5
	The driver holds gear	1,80	967	2	5
	The driver holds handbreak	1,54	392	1	5

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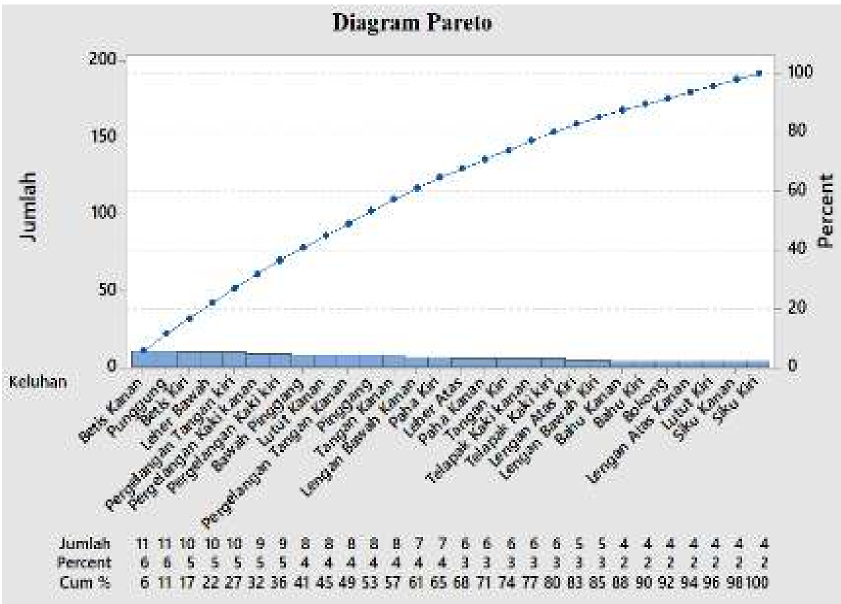
Driver Code	Activity	PEI	LBA	OWAS	RULA
2	Driver drives normally	2,19	1597	2	6
	The driver holds the turn signal light	2,18	1571	2	6
	The driver holds gear	1,88	1244	2	5
	The driver holds handbreak	1,42	547	1	5
3	Driver drives normally	1,73	729	2	5
	The driver holds the turn signal light	1,72	699	2	5
	The driver holds gear	1,70	612	2	5
	The driver holds handbreak	1,35	278	1	6
4	Driver drives normally	2,02	1024	2	6
	The driver holds the turn signal light	2,02	1022	2	6
	The driver holds gear	1,79	954	2	6
	The driver holds handbreak	1,372	368	1	5

Step 4 and 5: Adaptation and Sustain

Based on the pareto chart which is shown on Picture 1, 20% of driver pain-complained and most the highest level are on their right calf, back, left calf, and lower neck. Furthermore, the improvement of the driver seat will be focused on those four-body pain.

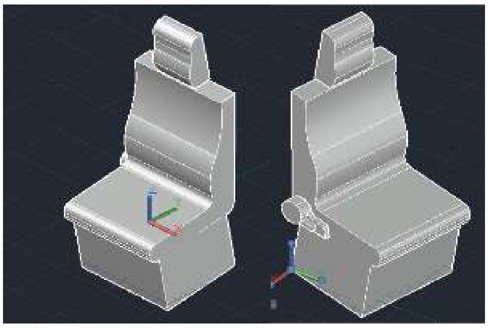


Picture 1. Pareto Chart of Body Pain

The redesign value of each seat location has been adjusted to the four driver's anthropometry data that been collected in the earlier step of this research. The final dimension of redesign seat can be seen at Table 7.

Table 7. Redesign Driver Seat Dimension

No.	Description	Dimension (cm)
1.	Head support length	10
2.	Seat depth length	37
3.	Seat length	44
4.	Head support height	27
5.	Chair height	89
6.	Seat height	40
7.	Seat thickness	10
8.	Backrest height	62
9.	Maximum backrest slope	105°
10.	Headrest width	20
11.	Seat width	46
12.	Backrest width	47



Picture 2. Design of a New Driver Chair

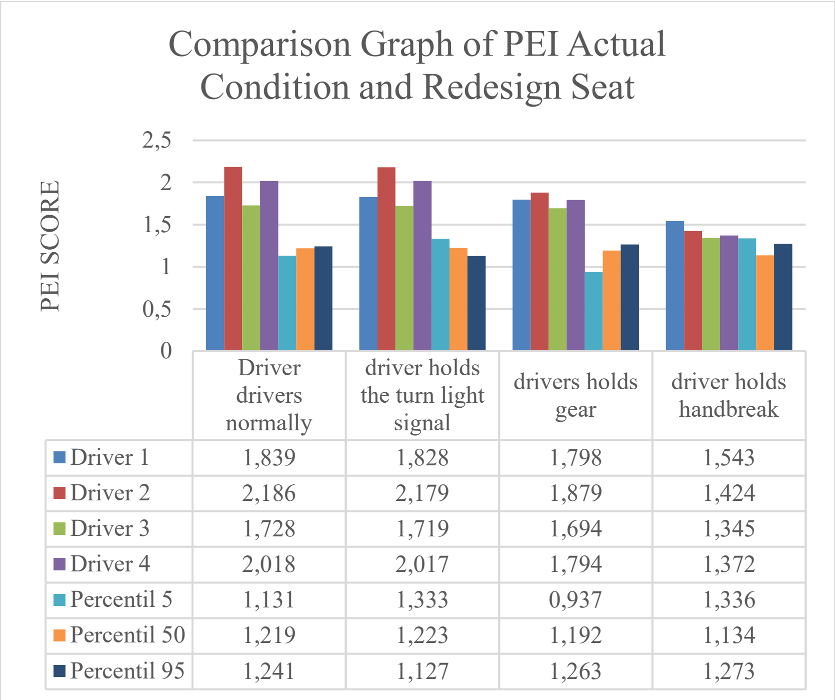
The redesign chair is shown in the picture 2, the chair is pointing out in the lower neck and adjust the back design. It is more likely human spine, so it has higher comfortable level than perpendicular chair design. It is also improved by using royal foam material on the seat backs, the headrests are famous for their springy texture and adjustable. Moreover, a slider will be made with a distance of 7 cm, so the users can adjust by theirself, more freely and more comfortable for their legs.

Based on the Table 8, the PEI value for all activities can be concluded having a better value than before. The value is less than 2, it means that the body posture while driving is increasing the safety value compared to real condition. This changing of actual PEI value is greater than the redesigned PEI value of the chair, with the largest actual PEI seat value of 2.186 , with a maximum

PEI value of 3.4. Values accessible to the actual PEI chair are not optimal in the design, not ergonomic, and provide a higher level of musculoskeletal financial disruption than the redesigned PEI value of the chair. Meanwhile, the maximum value of PEI index on the redesign chair is 1.336 which is lower than 2 and it is categoriezed as safer because the level of risk on musculoskeletal disorders are low. It can be conluded that the redesign chair are able to decrease the risk of musculoskeletal disorders, so it can be used as a suggestion design to make the next minibus driver's seat.

Table 8. PEI Score after Redesign Driver Seat

Percentile	Activity	PEI
5	Driver drives normally	1,131
	The driver holds the turn signal light	1,333
	The driver holds gear	0,937
	The driver holds handbreak	1,336
50	Driver drives normally	1,219
	The driver holds the turn signal light	1,223
	The driver holds gear	1,192
	The driver holds handbreak	1,134
95	Driver drives normally	1,241
	The driver holds the turn signal light	1,127
	The driver holds gear	1,263
	The driver holds handbreak	1,273



Picture 3. Graphics of Comparison PEI Actual Condition and Redesign Seat

4. Conclusion

By using NBM questionnaire that have been categorized into 4 scale, four highest points of driver pain can be detected. The highest part of human body pain was left calf, right calf, as much as 6%, while the left calf and lower neck as much as 5%. This data was used as a guidance to create some improvements design of the driver seat.

The normal driving activity in the actual condition detected the largest PEI parameter index value as much as 2.186. Then it can be categorized as middle-low musculoskeletal disorders and can be concluded that driving activity was not in optimal condition and not ergonomic. The result of redesigning chair has given optimal results. Considering by the largest PEI index parameter value as much as 1,336, so that the activity of handling hand brake were applying percentile of 5. The PEI index parameter category depended on the low risk of muscle damage. The redesign seats can be used in the manufacturing of the next minibus driver's seat.

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